

## **Infection prevention and control: A brief overview of theory and practice.**

### **Abstract:**

Nurses and the nursing profession continue to play a central role in infection prevention and control. The COVID-19 pandemic has highlighted the importance of controlling infection as well as the challenges in the care of patients with infections. This article discusses key elements of the theory and practice related to infection prevention and control, and includes contemporary challenges associated with risk assessment, personal protective equipment (PPE), surveillance and outbreak management.

**Keywords:** To be drawn from the Nursing Standard taxonomy.

### **Introduction:**

Infection prevention and control (IPC) refers to the policies, procedures, decisions and actions used to minimise the spread of infections (WHO 2021). The origins of formal efforts to control infection in nursing care can be traced to Florence Nightingale whose work helped reform hospital sanitation and pioneered work in epidemiology, while nursing sick and battle wounded soldiers of the Crimean war and beyond (Bostridge, 2020). The physician Semmelweis recognised the link between hand washing and sepsis mortality in obstetric patients (Kadar et al, 2018). His observations were initially dismissed; however hand washing is now a central component of IPC. Extensive efforts are now made to address potential reasons for clinicians not washing their hands (Gluyas 2015).

The challenges of controlling infection have only increased as a result of risks posed by antimicrobial resistance, hospital acquired infection and epidemics of novel pathogens rising due to increasing population density, globalisation and an ageing population (Bloom and Cadarette, 2019).

Efforts to control infections often involve a variety of professionals and organisations making the management of IPC complex. Nurses often undertake key roles in the control of infection including patient education, hand washing, use of personal protective equipment (PPE), undertaking or involvement in audits and providing clinical leadership during

outbreaks (Burnett, 2018). The recent COVID-19 pandemic has clearly highlighted both the importance of IPC and the challenges faced by clinicians trying to prevent the spread of infection (Peeri et al, 2020).

In the UK, and in recognition of the importance of IPC its mandatory provision is now a fundamental responsibility and legal obligation of modern healthcare providers as directed in the Health and Social Care Act (DHSC, 2012). It is also an explicit requirement for registered nurses and in England nursing associates to abide by recommended IPC practice and maintain their knowledge, skills and practice as per the NMC Code (2018). A robust knowledge of IPC theory and practice is therefore necessary for all nursing professionals to meet professional and regulatory obligations and protect themselves and their patients from avoidable infection.

### **Characteristics of organisms**

Knowledge of an organism's characteristics may inform risk assessments and subsequent interventions used to control or prevent transmission. According to Cox and Simpson (2018), without an ability to apply microbiology to decision making in IPC there is a risk of incorrect application of control measures and therefore a safety risk for both patient and professional by inadvertently increasing the risk of transmission. A study by Liu et al (2014) reported seven key competencies required of nurses related to basic microbiology for infection control:

- Understanding components required for transmission (chain of infection)
- Understanding different routes of transmission
- Ability to recognise clinical signs of infection
- Understand the concept of multi-resistant organisms
- An awareness of the variety of microorganisms and their differing modes of infection
- Ability to interpret basic microbiology reports
- Understanding the normal microbial flora of the body (the normal bacteria that cover the body)

## Chain of infection

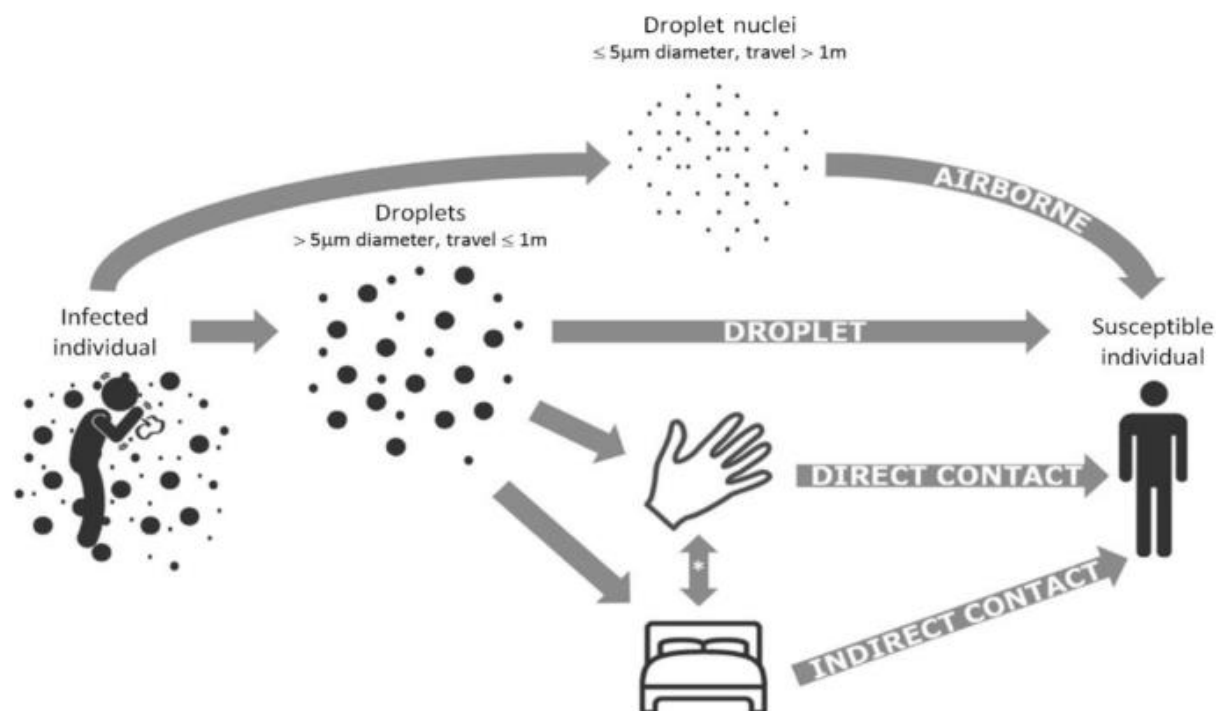
Components required for transmission are more commonly known as the 'chain of infection'. The chain of infection starts with the organism leaving its reservoir (e.g. people, food, water) via a portal of exit (e.g. in stool, vomit), is then conveyed by a mode of transmission (e.g. droplets) before entering through a portal of entry (e.g. mouth, through a cut) resulting in the infection of a susceptible host (Centers for Disease Control and Prevention (CDC), 2012). Preventing an infection requires the disruption of this chain. Standard precautions which include hand hygiene/decontamination, use of PPE, respiratory hygiene, the use of sharps boxes for safe disposal of needles, aseptic technique, use of sterile instruments and cleaning surfaces help to disrupt the chain and prevent infection (CDC, 2018). More specific transmission-based precautions may be required depending on the nature of the organism.

Transmission is broadly split into two types, direct and indirect (Wilson, 2019, p64). Direct transmission occurs via direct contact with the organism for example in body fluids via touch / kissing / contact with body lesions or contaminated surfaces. *Norovirus, measles and herpes* spread this way. Indirect transmission may occur if the organism can cause infection without human-to-human contact for example via droplets or airborne particles. Respiratory tuberculosis, influenza and the common cold are spread this way. Often organisms can infect via both direct and indirect methods requiring multi-faceted control efforts (Wilson, 2019).

The differences between airborne and droplet transmission have caused controversy during the COVID-19 pandemic not least due to the implications for IPC precautions (Shiu et al, 2019). Conventionally organisms that spread on smaller inspirable particles (droplet nuclei of  $<5\mu\text{m}$ ) are associated with airborne transmission, whereas organisms spread on larger droplets which cannot be inspired and do not travel as far are associated with droplet transmission (see figure 1). However, there is now debate around whether these two distinct modes of transmission exist or whether all organisms which spread via large droplets also spread via droplet nuclei (Fennelly, 2020). The potential of organisms within different bodily fluids to cause infection and the likelihood of exposure to these fluids while undertaking a procedure also needs to be considered in relation to the to the IPC measures

taken; for example, norovirus may be spread via contact with stool or vomitus by not via blood or respiratory secretions (CDC, 2019). Therefore, if a clinical procedure does not entail contact with the potentially infection-bearing fluid then all PPE barrier precautions may not be required. Crucially, the nature of the organism and its mode of transmission should inform risk assessments and any precautions or control interventions used.

Figure 1. (example diagram) Airborne vs droplet transmission (This diagram would need re-producing, I can't find the original source) -Definitions taken from Fenelly (2020)




## Risk assessments

Assessment of the risk of transmission is a critical element of IPC and requires a knowledge and understanding of both the nature of the organism and the available interventions (Wilson, 2019). For example, if a nurse plans to carry out a clinical procedure such as providing personal hygiene care, they must consider the risks posed by the procedure. This

may include contact with the patient's bodily fluids which carries a clear potential risk of direct transmission of any infectious organism present within these fluids. As such, standard precautions should be utilised to mitigate the risk (CDC 2018). Similarly, a risk assessment should be undertaken when deciding priorities as to which patients to isolate on a ward; the nature of the organism is critical in decisions like this. This will be based on reference to local protocols which will be based on best-practice guidelines such as Loveday (2014). A patient with a respiratory infection which can be transmitted indirectly via airborne droplet nuclei (e.g. respiratory tuberculosis) poses a clear risk to other patients and staff and would usually take priority over a continent patient carrying a carbapenem-resistant Enterobacteriaceae (CRE) when isolation facilities are at a premium.

Many decisions related to the control and prevention of infection require an assessment of risk which can range from bedside decisions over which PPE is required and who needs isolating or referring for a medical review, to higher level management decisions such as closing a ward or declaring an outbreak. Regardless of the level of decision-making the management of risk is based on the same principles known as the 'Hierarchy of Controls', as outlined in Table 1. In cases where risk assessments have not been undertaken as part of IPC policy or standard operating procedures a multi-disciplinary approach should be used (Wilson, 2019). Reducing risks posed by clinical procedures is dependent on a culture of safety and pragmatic approaches to mitigation which requires engagement from all clinical staff (Gluyas, 2015).

**Table 1. Hierarchy of Controls**

<div>Most effective</div> <div>  </div> <div>Least effective</div>	Strategy (Adapted by Wynn 2021, from The Centers for Disease Control and Prevention (2015))	Example
	Elimination (remove the hazard*).	Do not do the procedure if it is unnecessary or the risk is too high.  Early discharge of infectious patients from hospital.
	Substitution (replace the hazard*).	Undertake the procedure in a safer environment where more controls are in place, e.g. in an operating theatre.
	Engineering controls (Isolate people from the hazard*).	Use of needle safety devices (Ottino et al, 2019).  Use of negative pressure side-wards (Xu and Zhou, 2016).
	Administrative controls (change the way people work).	Adherence to policies and SOP.  Using a buddy system, e.g. when donning and doffing PPE (Reidy et al, 2017).  Consideration of human factors such as staffing levels, availability of equipment and ensuring staff are knowledgeable about risks (Gluyas, 2015).
	PPE.	Use of appropriate PPE including transmission-based precautions where necessary.

\*In this case the hazard is always onward transmission

## **Personal protective equipment**

PPE creates a physical barrier between the user and the organism and may consist of a variety of products including masks, gloves, gowns and aprons. It is therefore important for nurses to understand when and how PPE should be used (Brown et al, 2019). Following a risk assessment it may be necessary to adopt transmission-based precautions (TBP) which involve wearing PPE to protect against an organism with specific transmission characteristics (Wilson, 2019). This may include the use of a filtering facepiece (FFP) mask to protect against smaller airborne particles (airborne precautions), or a fluid resistant surgical mask to protect against larger droplets (droplet precautions).

Currently there is mixed evidence in support of the use of different types of PPE in different circumstances with many studies investigating the employment of PPE lacking a robust methodology. Available studies have used varying outcome measures, small sample sizes and poor study design (Verbeek et al, 2020). Current guidelines related to which PPE should be used in different scenarios is varied which may be due to both the lack of evidence for modes of transmission - particularly in relation to droplet and airborne routes - and low-quality evidence supporting the use of different types of PPE (Peters et al, 2020). It is therefore essential for nurses to make themselves familiar with their local organisation's policy and procedures related to PPE. Ultimately the choice of PPE should reflect both the transmission characteristics of the organism and the risks inherent in the procedure being undertaken.

When using PPE, special attention must be paid to doffing (taking off) procedures, which is when the risk of contamination to staff from the PPE is highest. According to Verbeek et al (2020) there is little robust evidence supporting any specific doffing procedure. However, spoken instruction while doffing and face-to-face instruction may reduce errors (Reidy et al, 2017). Human factors must be considered when doffing; clinicians wearing PPE for long periods of time may suffer from stress, fatigue and dehydration contributing to procedural errors (Verbeek et al 2020). Protocols developed by the British Armed Forces for medical

personnel working in Ebola treatment centres showed good effectiveness (Reidy et al, 2017). The authors reported that the use of PPE monitors who instructed and observed each person doffing helped prevent contamination of clinicians. A non-punitive culture, to enable a learning as opposed to a blame environment, which may encourage healthcare staff to hide and not improve poor practice or not ask for advice, must also be created to ensure IPC interventions such as the use of PPE and hand hygiene are effective, according to the World Health Organisation (Storr et al, 2017). Gluyas (2015) recommends that a code word could be used to highlight mistakes discreetly, thereby avoiding the stigmatisation of staff and could also be applied to the doffing of PPE. A more recent review reported that workplace culture, support from managers, training and access to equipment such as PPE are key factors affecting adherence (Houghton et al, 2020).

In addition to the risks of contamination from the use of PPE, nurses must consider the impact of wearing masks for prolonged periods on their skin integrity. Good skin care must be undertaken in addition to taking regular breaks to reduce the severity of lesions caused by masks (Zhou et al, 2020). Lesions caused by masks may increase the risk of infection to the wearer and compromise effective use of PPE, for example by more frequent touching and repositioning the mask to improve comfort. Risks of self-contamination by PPE are especially high at the neck, hands, wrists, and face (Suen et al, 2018). It is also necessary for future development of masks to account for variations in anatomy due to gender and ethnicity: statistically significant variations in injury prevalence have been reported during the COVID-19 pandemic which have been attributed in part to these design issues (Gefen and Ousey, 2020). Nurses may be unable to use PPE effectively if these issues are not addressed.

Finally, risks associated with over-use of PPE, particularly gloves, must be recognised. Wilson et al (2017) observed that non-sterile gloves are used inappropriately in around 59% of cases. Non-sterile gloves may prevent effective hand hygiene, and increase the risk of both dermatitis and cross-contamination leading to transmission of infection (Wilson et al, 2017). Nurses should be aware of these risks and only use PPE where the risk justifies the use, for example where there is a manifest risk of contact with bodily fluids (Loveday et al, 2014).



## Surveillance

Surveillance of antibiotic resistance and hospital acquired infections (HAI) is one of the most critical and expanding elements of IPC programmes and is considered a key competency of infection control nurses (Costa et al, 2021). Continuous review of clinical microbiological laboratory data is the most common surveillance method and essential to promote antibiotic stewardship, often defined as an organisational approach to using antimicrobials correctly to protect their future effectiveness (Dieckema and Saubolle, 2011). Other functions of surveillance include identifying outbreaks and targets for education related to commonly observed alert organisms (Dieckema and Saubolle 2011). An understanding of the importance of surveillance is needed to allow these processes to function effectively. Surveillance of emerging antibiotic resistant organisms such as carbapenemase-producing organisms (CPO) is necessary to allow prevalence and risk factor data to be obtained (Jain et al, 2014). Data from surveillance may influence the implementation of screening programmes carried out by nurses to help identify and mitigate the risks associated with the spread of these organisms (Otter et al, 2016). For example, surveillance-based research has helped guide screening programmes for carbapenemase-producing Enterobacteriaceae (CPE) and vancomycin-resistant enterococci (VRE) (both antibiotic resistance organisms) in adult inpatients (Wilson et al 2018). Areas with demonstrably high-prevalence of these organisms, such as hospitals in London and Manchester, screen for them regularly whereas areas with low prevalence may not in order to ensure that screening programmes are cost effective and reflective of local patterns of antimicrobial resistance (Wilson et al 2018).

There is a growing list of organisms which must be reported to the Nosocomial Infection National Surveillance Scheme (NINSS) as part of national surveillance schemes in England, including methicillin-resistant *Staphylococcus aureus* (MRSA), *Clostridium difficile* infection (CDI) and gram-negative blood stream infections, e.g. *Escherichia coli*, *Klebsiella spp*, *Pseudomonas aeruginosa* (Torok et al, 2018). Nurses need to be aware of the local screening policies associated with these organisms to ensure that data are not missed from surveillance reports, potentially exacerbating antimicrobial resistance.

Timely identification of outbreaks is another key role of surveillance. Outbreaks are typically defined as occurrences of infection in excess of expected cases, the number of cases varies

depending on the causative organism (Torok et al, 2018). Effective identification, reporting and analysis of data related to infections is therefore crucial for identifying outbreaks at all levels from hospital ward to regional level. The British government was criticised for the mishandling of data related to cases of COVID-19 during the pandemic and the subsequent impact this had on the ability of clinicians and surveillance professionals to identify outbreaks and implement control measures (Wise, 2020).

Recent advances in surveillance methodology have included the adoption of routine ‘whole genome sequencing’ (WGS) of COVID-19 patients as part of an ongoing study by the COVID-19 Genomics UK Consortium (COG-UK) (2020). This involves the genetic sequencing of viruses identified via swabs, allowing the production of highly accurate data, allowing for the exploration and identification of where the virus has come from and which other cases may be linked to it. WGS therefore has the potential to revolutionise the efficiency of outbreak management by allowing more timely recognition of cases which are linked based on similarities in the genetics of the causative organism, with clinicians being able to respond more rapidly and with a clearer understanding of how and where transmission is occurring.

### **Outbreak management**

Outbreaks of infection are increasingly common and often have both a high human and economic cost (Otter et al, 2017). Prevention is the ideal however, once an outbreak has been declared, a robust evidence-based approach should then be taken to manage the outbreak to prevent further spread of infection. The main stages of outbreak management can be seen in Table 2.

**Table 2. Outbreak Management**

Stages of management (from Torok et al, 2018)	Description	Role of nurse (from Siström and Hale, 2006)
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Identification of outbreak	Higher than expected incidence of infection identified by surveillance or from clinical observations, i.e. a high number of patients with diarrhoea on a ward.	Maintaining an awareness of local screening programmes to inform surveillance efforts.  Identifying and reporting cases of potentially infectious diarrhoea and / or vomiting and other suspicious trends in infection.
Investigation	Gathering samples and talking to patients who may be affected by the outbreak to determine the exact nature of the outbreak.	Collection of necessary diagnostic samples e.g. stool / respiratory swabs.
Case definition	Generation of a definition of patients affected by the outbreak. This usually includes criteria for person, place, time and clinical features and is specific to the outbreak under investigation.	Assessment and identification of patients who meet the case definition.
Control measures put in place	Measure implemented to limit further transmission and care for affected patients.	Education of patients / staff about mode of transmission, hygiene measures and medical care.  Evaluation of control measures via audit and discussion with patients and senior staff.
Communication	Communicating information related to outbreak to affected patients and staff.	Use verbal and written communication skills to communicate information accurately and sensitively to both lay audiences and professionals.

Outbreak management is a multi-disciplinary process requiring the concerted efforts of nurses and medical staff in addition to allied health professionals and managers; it is therefore important to recognise where information and knowledge are lacking which may hinder efforts to take appropriate action and control the outbreak.

## **Conclusion**

Threats posed by antimicrobial resistance and novel, emerging pathogens are increasing due to the impacts of increasing population density, globalisation and an ageing population. Nurses must respond to these challenges by adopting a more dynamic and pragmatic approach to IPC. Consideration of human factors when producing policy or undertaking IPC interventions must prevail over punitive approaches when evaluating IPC practice. Awareness of nurses' roles in key processes such as surveillance and outbreak management is essential to ensure the efficacy and efficiency of these activities.

New surveillance methods including WGS have the potential to hasten the identification of outbreaks allowing nurses to respond more rapidly. To improve the safety of staff and patients a multidisciplinary team approach should be taken when undertaking risk assessments related to infectious hazards, recognising where scientific evidence or knowledge is lacking and acting accordingly. Changes are needed to the design of supplied PPE masks to account for the diversity of staff using them to limit damage to skin integrity, improve adherence to PPE procedures and ultimately increase both staff and patient safety. Finally, more research is needed to explain the exact nature of transmission of respiratory pathogens and how PPE can be used most effectively by staff caring for patients with infections.

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